PLANETARY VOLATILES EXTRACTOR (PVEX): IDEAL SYSTEM FOR IN SITU RESOURCE UTILISATION (ISRU) AND DELIVERING VOLATILES DIRECTLY TO GCMS.

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Introduction: Capture of volatiles on the Moon or other planetary bodies is critical to analyzing local regolith as well as critical to In Situ Resource Utilization or ISRU.

Planetary Volatiles Extractor (PVEx) is a drill-based volatiles extraction system; see Figure 1 [1]. It can be used to capture volatiles for delivery into science instruments such as GCMS or it could also be used to mine large quantities of volatiles for ISRU purposes (e.g. mining water for H2/O2 rock fuel). PVEx is powered by the TRL6 TRIDENT drill developed for the Resource Prospector mission [2]. TRIDENT underwent extensive testing at NASA GRC, KSC, and JSC. The drill was tested in a lunar vacuum chamber at -150C and 10^-6 torr vacuum in ice-bound lunar regolith simulants as well as on vibration tables and RP rover.

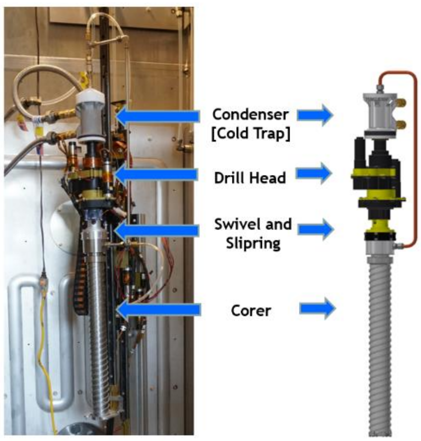

Figure 1. PVEx inside a vacuum chamber.

The main difference between the TRIDENT and PVEx is the type of the auger drill. TRIDENT uses a 1-inch deep fluted auger to capture and deposit regolith samples into GCMS cups. PVEx, on the other hand is a coring auger with internal heaters – it drills a regolith core and heats it up to liberate volatiles, in-situ (the drill is never retracted). Volatiles then flow up the hollow auger and through the swivel into either a GCMS or a cold trap. PVEx essentially eliminates regolith handling altogether; volatiles from the regolith are never excavated. PVEx can drill 10 cm, heat up the regolith, and then drill another 10 cm. By doing so it can provide volatiles concentration as a function of depth. After reaching the final depth, PVEx is reacted and the dry regolith core collapses and stays behind in a hole.

Eliminating sample handling significantly cuts down on time and power, as well as overall mission complexity. Handling of volatile rich regolith in vacuum almost always leads to some volatiles loss. Hence by the time a sample is delivered to a GCMS, it no longer represents the subsurface. PVEx solves this problem since all the volatiles are delivered from the subsurface to the instrument.

Preliminary testing: Several tests have been conducted in ice-bound NU-LHT-2M (lunar highlands simulant). Testing included drilling into the regolith, heating it up, and either capturing of volatiles in a cold trap (for ISRU) or filling a Mylar balloon which represented GCMS. Initial tests have been very promising. PVEx penetrated icy regolith (5 wt%) at a rate of approximately 1-2 cm/min and at power levels of approximately 100 Watts. As shown in Figures 2 and 3, PVEx also captured water in its cold trap and inflated a balloon in just over a minute, during another test. The tests will continue for the next several months to fine tune drilling and heating parameters.

Figure 2. Water captured by PVEx

Figure 3. PVEx can delivered volatiles to GCMS. Shown is a Mylar balloon inflated in ~1 min.

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References. [1] Zacny et al. (2016), Planetary Volatiles Extractor (PVEx) for ISRU, ASCE E&S [2] Paulsen et al., (2018), The Regolith and Ice Drill for Exploration of New Terrains (TRIDENT); a One-Meter Drill for the Lunar Resource Prospector Mission, 44th AMS.